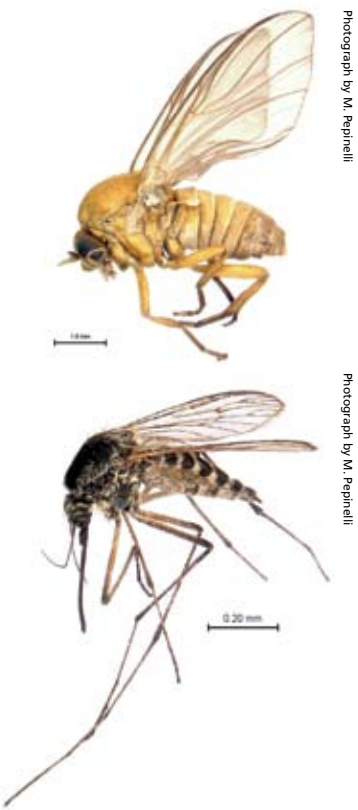
# Barbarians at the Gate: Biting Flies of Beringia

**By Peter H. Adler and Douglas C. Currie**



Photograph by M. Pepinelli

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**Figure 2. (Above Top) Myth buster: Although the name implies that all black flies are black, a small number of species are orange, including the large, pestiferous females of Alaska's *Prosimulium fulvum*.**

**Figure 3. (Above Bottom) Female mosquito of the genus *Aedes*, one of about 23 species of mosquitoes in Beringia that savage humans and other homeotherms.**

**Figure 1. (Left) The vast, open landscape of Beringia is dissected and pock marked by streams and pools, providing fertile breeding grounds for more than 80 species of black flies and mosquitoes.**
Photograph by D.C. Currie

For blood-sucking flies, the Far North is a paradise of food and breeding habitat, but for the animals and humans that reluctantly furnish the blood, the Far North is hell on Earth (*Figure 1*). The world's largest populations of black flies (*Figure 2*) and mosquitoes (*Figure 3*) are found in northern regions of the globe, where densities of larval black flies can exceed 600,000 larvae per square meter of streambed, and populations of even a single species of mosquito can reach unsettling densities of more than 30 million adults per hectare. Legendary for their blood-sucking habits and noxious behavior of ceaselessly swarming around their hosts (*Figure 4*), biting flies are responsible not only for enormous economic losses but also for the limited extent to which northern regions have been inhabited and developed (*Adler et al. 2004*). They can suppress tourism and gouge the economy of afflicted communities. They can be so vexatious to wildlife that the timing and extent of migrations of animals such as caribou are significantly altered. Biting flies also routinely transmit microorganisms that cause wildlife diseases such as avian malaria and leucocytozoonosis.

Although adult biting flies can have a negative effect on humans and wildlife, they also play an integral role in the environment as pollinators, food for predators such as songbirds, and regulators of wildlife populations (*Malmqvist et al. 2004*). There is also the controversial perspective that biting flies are some of the finest conservators of northern habitat, limiting settlement and development in environmentally sensitive areas. The immature stages of biting flies are innocuous, but important, components of the aquatic food web and are useful indicators of water quality, often providing the first signs that an aquatic habitat is polluted. Larval black flies (*Figures 5-6*) have been called "ecosystem engineers" because of their vital role in processing dissolved and particulate organic matter into larger fecal pellets used as food by other aquatic organisms (*Malmqvist et al. 2004*).

Despite the prominent role that biting flies play in the economies and ecosystems of northern regions, the individual species remain poorly known. This paradox can be explained by the logistical problems of conducting research in the vast expanse of the Far North, by independent efforts of scientists on either side of the Bering Strait, and by past technical limitations in distinguishing similar species. Alaska, for example, has 63 recorded species of black flies, but prior to our work, only 10 species were known west of Fairbanks, a significant underestimate of the area's true biodiversity (*Adler et al. 2004*). Thirty-two species of mosquitoes have been recorded from Alaska, with 18 known west of Fairbanks (*Darsie and Ward 2005*).

A major factor hampering an understanding of Beringian biting flies has been the largely independent efforts of North American and former Soviet researchers. Working in scientific isolation, researchers on different sides of the Bering Strait often gave the same species of fly different scientific names, obscuring faunal similarities and common experiences of the people and wildlife exposed to the pest species. The extent to which the species of biting flies are shared between Russia and North America remained unknown because the most critical areas, western Alaska (eastern Beringia) and Far East Russia (western Beringia)—physically connected as recently as 11,000 years ago and now separated by a mere 52 miles (84 km)—were poorly surveyed for biting flies.

Photograph by D.C. Currie

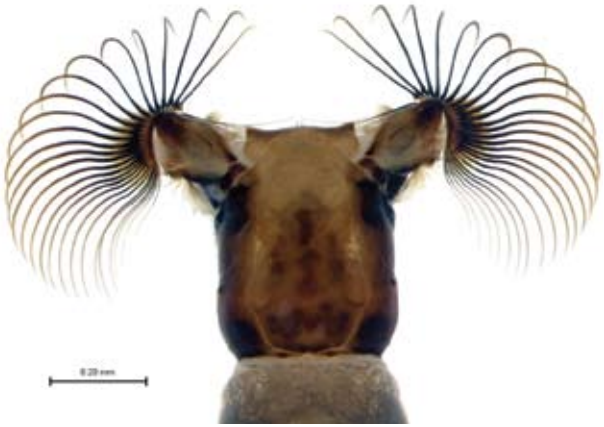
**Figure 4. Bane of Beringia: mosquitoes.**

Similarities in the biting fly fauna on the two sides of the Bering Strait would suggest that certain experiences, traditions, and cultural practices related to biting flies, such as the use of natural repellents and spiritual beliefs, also might be shared. Because biting flies can negatively impact reindeer (caribou) populations, they could affect the economy of some inhabitants of Beringia that rely on reindeer herding. Reindeer herding remains a viable industry and important part of the non-maritime Chukchi culture in Chukotka, where about a half million domesticated reindeer live; in fact, "Chukchi" means reindeer people.

Under the auspices of the Shared Beringian Heritage Program of the National Park Service, we began a multifaceted investigation of the biting flies of Beringia, focusing particularly on black flies, the more poorly known of the biting flies. To test the hypothesis that the Beringian black fly fauna includes a greater number of shared species than heretofore recognized, we sampled biting flies over a period of two years, concentrating in the heart of Beringia, roughly Alaska west of the road network and Far East Russia east of the Anadyr River. Beringia is a largely undeveloped land, difficult and expensive to access and traverse. Consequently, we used several less conventional modes of transportation including float planes, rafts, and track vehicles (*Figure 7*), and chose sampling areas that would provide the broadest range of topography and habitat. Our Alaska research took place in 2005 and 2006 on the Seward Peninsula, around Bethel, and along the 130-mile (210-km) Kisaralik River. Our research in Russia was carried out in July 2006 along the Andayr River from its confluence with the Belaya River to Anadyr, the capital city of Chukotka. Larval and pupal biting flies were sampled from seepages, streams, rivers, tundra pools, and lakes along these routes. Specimens were hand collected, using fine-tipped forceps, from all available substrates (e.g., rocks and vegetation) in the flowing waters (*Figure 8*) and by using aquatic dip-nets in standing waters.

Many species of biting flies are structurally similar to one another. To discover these look-alike species and test faunal similarities within and between eastern and western Beringia, we used a two-pronged approach involving cytogenetic and morphological techniques. Larvae and pupae were collected into Carnoy's solution (1:3 acetic acid: ethanol) for subsequent analysis of the banding patterns in the giant larval silk-gland chromosomes and in 95% ethanol for morphological study. Adult biting flies were collected with aerial nets and placed in 95% ethanol or pinned in the field. We linked the adult flies with their immature stages and associated breeding sites by rearing pupae to adults in small petri dishes lined with moist filter paper. Each species of black fly was categorized as a bird feeder or mammal feeder, based on the design of the female's claw, which has a thumblike lobe in bird feeders, but is a simple curved talon in mammal feeders. Our specimens were identified, cataloged, and deposited in the Clemson University Arthropod Collection in South Carolina and the Royal Ontario Museum in Toronto, Ontario, to serve as a permanent record of the Beringian biting fly fauna and a resource for future researchers.

We found 56 species of black flies in the heart of Beringia, 40 in eastern Beringia and 37 in western Beringia. At least 55% of the species are shared. Twenty-three species of mosquitoes occupy Beringia, with 18 eastern, 26 western, and 70% shared. Of the 56 species of black flies in Beringia's heartland, 23% acquire blood from birds and 45% from mammals, whereas 32% do not take blood, having mouthparts too weak to cut flesh. Those black flies that do not take blood must acquire their energy during the larval stage. The percentage of species without biting mouthparts is the highest for any area of the world, exceeding even that of Canada's Barrenlands (26%). Time not spent locating a host and acquiring a blood meal



Photographs by M. Pepinelli

**Figure 5. (Left) The larval head of most black flies, such as *Prosimulium neomacropyga*, is fitted with a pair of labral fans for filtering particulate matter from the water current. When the fans have captured sufficient food, the larva folds them toward the mouth and scrapes off the adherent material.**

**Figure 6. (Right) Larvae of the Beringian endemic *Gymnopais dichopticus*, and seven other species of black flies, do not have fans for filter feeding, instead scraping their food from stones to which they adhere in flowing water.**

Photograph by D.C. Currie

**Figure 7. Sampling for biting flies in Beringia can require unconventional means of transportation, such as track vehicles in Chukotka, Russia, to reach a variety of habitats. Here the driving crew has set up lunch by a collecting station for the authors.**

Photograph by P.H. Adler

**Figure 8. A typical cold-water stream on the Nome-Taylor Road yields two species of black flies. The author (Currie) samples prime microhabitat—a stone in a riffle.**

Photograph by D.C. Currie

**Figure 9. Alaska streams and rivers emptying into the Bering Sea across the Strait from Russia produce prodigious numbers of black flies that could be transported to Chukotka on the wind. The author (Adler) samples larval black flies from stones in a small stream that produced eight species.**


**Figure 10. Barbarian at the gate: *Simulium vittatum*, a pest of humans and domestic animals, is common in eastern Beringia but has not yet crossed the Bering Strait.**

Photograph by M. Pepinelli

is time devoted to reproductive effort in an extraordinarily harsh environment subject to the vagaries of weather. Two Beringian black flies have taken environmental independence a step further. Not only have they eliminated the need for blood, but also the need to mate; males of these species do not exist, and reproduction is by virgin birth (parthenogensis).

Beringia was a cradle of biodiversity in the Far North, with numerous species dispersing from Beringia as the ice sheets melted. We have consistently found that each species of black fly is more genetically differentiated as the distance east of Beringia increases. Approximately 58% of the species of black flies in western Alaska are shared with Russia, whereas about 70% of the species in Far East Russia are shared with Alaska. In other words, all but 11 of Far East Russia's 37 species also occur in North America, but only 23 of our 40 western Alaska species occur in Russia. Whereas most Beringian black flies are widely distributed in the northern hemisphere, seven species are endemic to Beringia, occurring nowhere else in the world. No mosquitoes, however, are Beringian endemics.

Although Beringia was the main source area for black flies that repopulated northern North America after deglaciation, it also received a substantial number of immigrant species from southern refugia. Among these immigrants are several major pest species of humans and domestic animals. These immigrant pests boil from the rivers and streams of eastern Beringia (*Figure 9*), yet none have managed to cross the Bering Sea into easternmost Russia.

But the barbarians are at the gate. Our previous work has shown that distances of less than 62 miles (100 km) are not a major obstacle to black fly dispersal (*Adler et al. 2005*). Species, including pests, from southern areas of North America have worked their way northward following the Wisconsinan glaciation, a process likely to continue with global warming. Insects, including biting flies, with their strong dispersal abilities and short generation times, track climate change far more quickly than most organisms. One of these species, *Simulium vittatum* (*Figure 10*), is among North America's most abundant and widespread black flies and is a significant pest of humans and large mammals. This species and others are poised to colonize the opposite side of the Bering Strait. We now have the baseline data to monitor ongoing changes in the Beringian biting-fly fauna as climate change continues.


## Acknowledgements

We thank the Shared Beringian Heritage Program of the National Park Service, which supported the research of Adler, and the ROM Reproductions Acquisitions and Research Fund, which supported Currie. We also thank Mateus Pepinelli for the photomicrographs of some of our specimens.


## REFERENCES


**Adler, P.H., D.C. Currie, and D.M. Wood. 2004.**
*The Black Flies (Simuliidae) of North America.* Cornell University Press. Ithaca, NY.

**Adler, P.H., D.J. Giberson, and L.A. Purcell. 2005.**
*Insular black flies (Diptera: Simuliidae) of North America: tests of colonization hypotheses.* Journal of Biogeography 32: 211-220.

**Darsie, R.F., Jr., and R.A. Ward. 2005.**
*Identification and Geographical Distribution of the Mosquitoes of North America, North of Mexico*. University of Florida. Gainesville. FL.

**Malmqvist, B., P.H. Adler, K. Kuusela, R.W. Merritt, and R.S. Wotton. 2004.**
*Black flies in the boreal biome, key organisms in both terrestrial and aquatic environments: a review.* Écoscience 11: 187-200.